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# CONDITIONED TASTE AVERSION IS NOT DISRUPTED IN RATS EXPOSED TO WEAK, COMPLEX MAGNETIC FIELDS DURING THE CS–UCS INTERVAL[1]

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*Summary.*—40 normal male Wistar rats were trained for 8 successive days to consume water *ad libitum* during once-daily 20-min. sessions. On the following day (training day) the rats were presented with a novel solution of 10% sucrose for 20 min. followed by a single exposure for 2 hr. to one of two weak (200 to 500 nano-Tesla) complex magnetic fields or to sham-field conditions. The patterns of the two magnetic fields and the durations of their repeated presentations (interstimulus interval) were designed to be resonant with the intrinsic firing of hippocampal pyramidal and solitary neurons, respectively. Immediately after the applications of the fields one-half the number of rats were injected with lithium to evoke gastrointestinal malaise. Although on the test day, three days later, rats previously injected with the lithium exhibited the usual robust reduction in the consumption of sucrose compared to the training day, there were no statistically significant differences between field-exposed and sham-field groups for these ratios. We conclude that a 2-hr. exposure to weak magnetic fields designed to simulate the pattern of two structures likely involved with conditioned taste aversion between the conditioned stimulus and the unconditioned stimulus did not affect this behavior.

The strong magnetic fields employed for Transcerebral Magnetic Stimulation (TMS), whose intensities are within the Tesla range, are known to attenuate conditioned taste aversion in rats (Kling, Yarita, Yamamoto, & Matsumiya, 1990). However, previous research has suggested that extremely weak magnetic fields, more than a million times less intense, can modulate behavior if the shape of the applied wave form was modelled after the intrinsic electromagnetic properties of the brain structure whose function is most strongly correlated with the task (McKay, Persinger, & Koren, 2000).

A preponderance of the scientific literature (Yamamoto, Shimura, Sako, Yasoshima, & Sakai, 1994) has implicated the nucleus of the solitary tract, via its projections to the parabrachial nucleus, in mediating the association between the representation of a novel taste (the conditioned stimulus) and lithium-evoked gastrointestinal malaise (the unconditioned stimulus). On the other hand experimental interventions that produce excitotoxic neuronal loss following seizures induced by a single systemic injection of lithium and pilo-

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carpine have strongly implicated a role of the hippocampal formation (Persinger, Bureau, & Peredery, 1994). Because both of these structures are well characterized by discrete electrical patterns when measured in freely behaving animals, the present study was designed to test the hypothesis that magnetic wave forms constructed to affect these intrinsic signatures might affect the intensity of conditioned taste aversion in the rat.

Because the applied fields were not phase-locked with the intrinsic electrical signatures of the neurons within the structures, we expected that, were our experimental patterns sufficiently similar, any "resonance" effect would interfere with these patterns and diminish the intensity of the conditioned taste aversion. Following eight days of 20 min./day of access to tap water, male Wistar rats ($N=40$; approximately 12 to 14 months of age) were given a novel sucrose (10%) solution for 20 min. During the 2-hr. postconsumption period they were exposed to one of the two magnetic patterns or the sham field. The equipment has been described elsewhere (Stewart & Persinger, 1999).

In Exp. I half the number of rats were exposed to a sham field while the other half were exposed to theta-burst stimulation modelled after a sequence known to evoke long-term potentiation in hippocampal slices (Rose, Diamond, Pang, & Dunwiddie, 1988). The point duration of the column of numbers between 0 and 255 whose values were transformed from the computer program by a digital-to-analogue to specific voltages to generate the magnetic fields was 1 msec. The pattern was delivered continuously. In Exp. II half of the rats were exposed to the sham field while the other half were exposed to a burst-firing pattern (Richards, Koren, & Persinger, 1992) modelled after the intrinsic electrical patterns of neurons within the solitary tract. The point duration was 3 msec., and the time between presentations of the pattern was 10 sec. The latter was based on the report by Paton, Li, Deuchars, and Kasparov (2000).

Following the 2-hr. treatments with the complex or sham fields, half the number of rats in each group were injected intraperitoneally with .15 M of lithium chloride (10 cc/kg) to evoke gastrointestinal malaise. The remaining rats were left untreated as the reference group. Because conditioned taste aversion from this procedure is so robust, we did not inject saline into the other rats. We decided to test the hypothesis that simply exposure to the fields following consumption of sucrose (with minimal confounding factors from "stress") would affect subsequent sucrose consumption.

Rats were returned to the 20 min./day water schedule for two successive days. Three days after the initial pairing rats were again presented with the sucrose solution. A ratio of the volume (mL) of sucrose on the nonpairing (testing) day to the volume of sucrose consumed on the lithium-pairing (training) day was computed. To attenuate the effects of extreme scores and

to satisfy the conditions of homogeneity of variance the two outliers were truncated to values that were two standard deviations above the mean.

Two-way analysis of variance (lithium vs untreated; magnetic field vs sham field) were completed separately for each experiment. The means and standard errors of the mean for each group are shown in Table 1. There were statistically significant reductions in the amount of sucrose water consumed on the testing day compared to the training day for rats injected with the lithium compared to the reference group for both experiments ($F_{1,16} = 88.30$, 63.40; $p < .001$). There were no statistically significant differences between the groups exposed to the magnetic fields vs the sham fields. The interactions between the injections of lithium chloride and field treatments were also not statistically significant ($F_{1,16}$s $< 1.08$).

TABLE 1

MEANS AND STANDARD ERRORS OF MEANS (*SEM*) FOR RATIO OF SUCROSE CONSUMPTION (TESTING DAY VOLUME IN mL RELATIVE TO TRAINING DAY VOLUME IN mL) FOR RATS EXPOSED TO SHAM CONDITIONS OR TREATED WITH EITHER A HIPPOCAMPAL-MODELLED THETA-BURST STIMULATION (TBS) PATTERNED OR SOLITARY TRACT NEURON MODELLED BURST-FIRING (BURST) PATTERNED MAGNETIC FIELD WAVEFORM

| Group | Experiment I | | Group | Experiment II | |
|---|---|---|---|---|---|
| | *M* | *SEM* | | *M* | *SEM* |
| Lithium/Sham | 0.38[a] | .02 | Lithium/Sham | 0.48[a] | .08 |
| Lithium/TBS | 0.46[a] | .11 | Lithium/Burst | 0.56[a] | .09 |
| Control/Sham | 1.08[b] | .04 | Control/Sham | 1.39[b] | .14 |
| Control/TBS | 1.07[b] | .07 | Control/Burst | 1.26[b] | .09 |

*Note.*—Following 2 hr. of magnetic field or sham treatments, gastrointestinal malaise was evoked by lithium or rats were left untreated as a reference (Control). Within each experiment [a] vs [b] Scheffé's *post hoc* $p < .01$.

Recently, Choleris, Thomas, Ossenkopp, Kavaliers, Valsecchi, and Prato (2000) reported that a weak intensity, frequency-modulated magnetic field had no effect upon conditioned taste aversion in deer mice. The present results extend these results to additional waveforms. However, Choleris, *et al.* (2000) and Choleris, Persinger, Thomas, Kavaliers, Ossenkopp, and Prato (1997) reported that their frequency-modulated waveform enhanced the taste aversion preference for two different novel solutions using two different exposure systems to apply the waveforms (one of which was employed in the present study). The latter report provides strong evidence that alterations in taste preference are specific to the applied waveform and not simply a nuance of the equipment used to generate the complex magnetic waveform.

Given that Kling, *et al.* (1990) found that the strength of conditioned taste aversion could be attenuated by a very intense magnetic field, about one million times stronger than the ones employed in the present study, intensity of the field may be more important for affecting this form of condi-

tioning. The threshold for this intensity must still be established. However, it may be relevant that in both of the present experiments conditioned taste aversion of the rats exposed to the 200 through 500 nT (5 mG) magnetic fields was attenuated by about 18%. This small difference would be statistically significant only with sample sizes of more than 50 rats per group. The practical implications, if any, would be most applicable within large ecological contexts.

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